I-16

Magnetic resonance force microscopy of individual domain wall

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We report on resonance force microscopy (MRFM) [1] investigations of the ferromagnetic resonance (FMR) of single domain wall (DW) in V-shaped planar permalloy nanowire (NW).

The magnetic permalloy 60°-bent V-shaped NWs (with shoulders of 3000 nm long and 600 nm width) were fabricated on 100 μm thick glass substrates. The samples were defined by e-beam lithography, metallization, and lift-off of 30 nm $Ni_{80}Fe_{20}$ layer deposited using a dc-magnetron sputtering technique. Scanning electron micrograph (SEM) of a V-shaped NW is shown in Figure 1a. In these NWs DWs can be easily created by external magnetic field applied along x-axis (Fig. 1b).

In our MRFM, a nearly spherical Co probe with diameter of ~9 μm attached to the end of a cantilever is used to localize region in which FMR is excited by the microwave strip-line inductor. In this region, the sum of the internal magnetic field and the *x*-component of the probe magnetic field corresponds to the resonance condition of DW. The field gradient produced by the probe couples the modulated high frequency component of magnetization to the cantilever that serves as a resonant (on the modulation frequency) micromechanical force detector. The high-quality factor (~10^4 in vacuum) of the mechanical resonator provides its unique sensitivity.

The example of the MRFM spectrum of DW is presented in Figure 1c. The corresponding MRFM image of the sample area at resonant frequency is presented in Figure 1e which shows that the resonance excitations are strongly localized in the DW region of NV. The resonance spectra and spatial distributions of the resonant oscillation amplitude were calculated by numerical solution of Landau-Lifshitz equation [2]. The measured MRFM spectrum and spatial distribution of resonant mode signal agree with micromagnetic modeling (Fig. 1c,d).

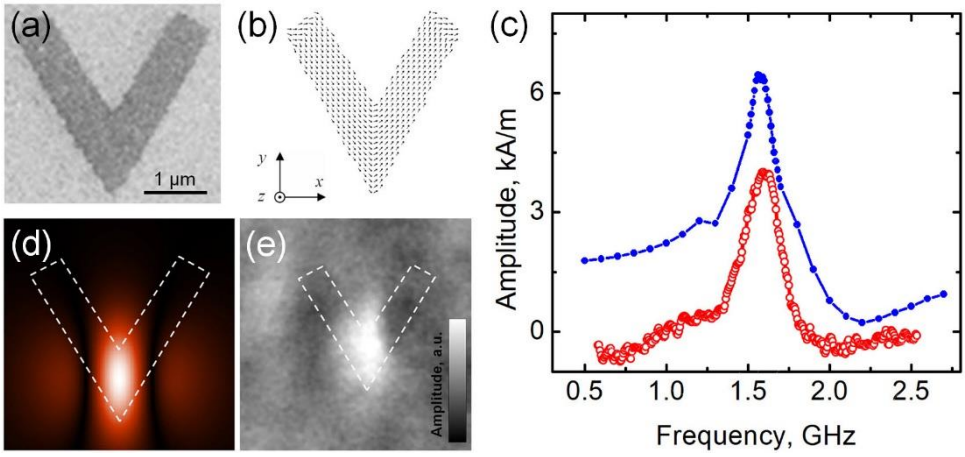

Figure 1. (a) SEM image of the Ni80Fe20 V-shaped NW. (b) Simulated distribution of magnetization in NW after magnetizing in x-direction. (c) MRFM spectra measured (lower curve) and modeled (upper curve) at H = 50 Oe aligned along the film plane perpendicular to DW. (d) Spatial distribution of the simulated amplitudes of the MRFM signal. (e) The MRFM image acquired at a DW resonant microwave frequency of 1.6 GHz.

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1. Z. Zhang, P. Hamel, P. Wigen, *Appl. Phys. Lett.* **68**, 2005 (1996).
2. R. Gorev, E. Skorokhodov, V. Mironov, *Phys. Solid State* **58**, 2212 (2016).